Does Cash Really Mean Trash? An Empirical Investigation into the Effect of Retailer Price Promotions on Household Food Waste

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Retailer price promotions, and in particular multi-unit deals such as the ubiquitous "buy one, get one," are often criticized as a cause of food waste, presumably because they lure households into buying more than they can realistically consume. In this research, the authors combine field data and experiments to provide the first systematic test of this claim. The field data, which span eight frequently purchased perishable foods, show no evidence of a positive relationship between single-unit or multi-unit price promotions and food waste. In fact, households that took advantage of a multi-unit deal reported wasting less than did households paying regular prices (RPs), but only when the quantity purchased was larger than usual. Given this result, and that households also reported consuming and freezing more, the authors hypothesize that promotion-induced overbuying triggers a concern for food waste that encourages waste prevention. One experiment finds support for this mechanism. A second experiment shows that the effect on food waste concerns is moderated by perishability and versatility but unaffected by convenience and healthiness. Overall, then, this research invites regulators and other professionals to rethink their stance on price promotions and work with retailers to design smart campaigns that motivate waste awareness and management.

Keywords: household food waste, price promotion, multi-unit deals, waste aversion, overbuying

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Each year, close to 1.3 billion tons of edible food, or roughly one-third of global food production intended for human consumption, is cast off, left to spoil, or simply lost (FAO 2019). The consequences of this negligence are extraordinary. The annual economic cost alone stands at an estimated $1.2 trillion (Hegnsholt et al. 2018)—with the average American spending about $1,300 a year on food that is not eaten (Conrad 2020). Food waste also drains scarce natural resources: food loss "from farm to fork" accounts for 8% of total greenhouse gas emissions (European Commission 2020). Finally, from a moral standpoint, many object that societies scrap food when over 820 million people worldwide are underfed (World Hunger Education Service (WHES) 2018).

About 61% of food waste occurs at the household level (United Nations Environment Programme (UNEP) 2021a), and supermarket retailers are often criticized for exacerbating the problem with price promotions—especially multi-unit deals such as the ubiquitous "buy one, get one"—that lure shoppers into making larger purchases than they otherwise would. For instance, a UK House of Lords committee calls for multi-unit promotions (MUPs) to be scrapped: "We are urging the supermarkets to look again at offers such as 'buy one, get one free,' which can encourage excess consumption which leads to food waste" (*The Guardian* 2014). A study conducted by Boston Consulting Group concludes "excess purchasing by consumers is encouraged by grocery promotions. This drives up food waste because consumers are often unable to consume all their purchases before they go bad" (Hegnsholt et al. 2018, 3). Finally, a report by the US National Academies of Sciences, Engineering, and Medicine advises retailers to "develop promotions and other in-store cues that prioritize acquisition of the optimal amount and variety (including frozen, shelf stable, and perishable) of products rather than prompting over-acquisition" (NASEM 2020, 8).

The key assumption underlying this criticism is that larger-than-usual purchases (i.e., overbuying) are excessive and, therefore, inherently wasteful. But this logic is not necessarily supported by academic research. In fact, marketing scholars can point to studies showing that promotion-induced overbuying prompts households to accelerate and increase consumption and store some of the extra quantities for future occasions (Ailawadi and Neslin 1998; Ailawadi et al. 2007; Chandon and Wansink 2002), which would appear to mitigate food waste.

The problem with these studies, though, is that none measures food waste. Rather, the typical analysis uses purchase quantities and interpurchase times collected from scanner panel data only to infer consumption rates, thereby implicitly assuming that every unit of food purchased is eaten at some point. Waste is clearly one possible outcome of the post-purchase experience of households, but we cannot understand its relation to price promotions with purchase data alone. We need insight into how households handle food in their homes.

In light of the importance of the phenomenon, and the lack of evidence on whether food purchased under one price regime or another is actually scrapped, there have been several calls to clarify the relationship and its underpinnings (Block et al. 2016; Porpino 2016; van Doorn 2016). In one commentary, for example, van Doorn (2016, 54) observes "Studies provide anecdotal evidence that price promotions lead people to impulsively buy more than they need and to waste more and expect 'buy one, get one' promotions to fuel food waste… However, large-scale studies investigating the extent to which in-store stimuli and (different types of) price promotions contribute to food waste are lacking." This is the goal of our research.

The next section reviews the relevant literature. We then report a large-scale field study conducted in collaboration with market research agency GfK. Across 9 weeks, households shopping at Albert Heijn, the largest supermarket retailer in the Netherlands, encountered eight pre-selected, frequently purchased perishable foods sold at their RP, on a single-unit promotion (SUP), or on a MUP. Households who purchased these foods later described how they were used, including whether any portion was discarded.

In the data, households that took advantage of either deal did not report wasting more than did households paying RPs. In fact, we find that food purchased on a MUP was wasted less than food purchased at its RP, while consumption and freezing increased significantly. We cannot attribute these effects to price promotions attracting households that consume larger quantities or are intrinsically more frugal or averse to waste. Rather, we suggest that overbuying is a factor, as the effects are attenuated when, for a given household, the quantity purchased on a multi-unit deal is similar to the quantity typically purchased at RPs.

To account for this finding, we propose a theory of waste prevention rooted in the idea that promotion-induced overbuying prompts a concern for food waste. Food waste aversion has been conceptualized as a personality trait (Le Borgne et al. 2021; Raghunathan and Chandrasekaran 2020), but one can also envision settings where the purchase context triggers a similar concern that is independent of people's dispositions, as has been shown in a few studies in domains other than food (Arkes 1996; Okada 2006). We believe that this logic applies to price promotions when they prompt people to purchase larger quantities than they typically do. Specifically, we argue that MUPs, which are naturally associated with overbuying, trigger waste aversion and influence how people later handle food to avoid waste.

In one experiment, we show that, compared to RPs and SUPs, MUPs prompt food waste concerns (FWC) and, in turn, FWC cause waste-preventing behaviors including accelerated and increased consumption and more freezing. Then, a second experiment tests the generalizability of the link between MUPs and FWC across 96 foods varying in convenience, healthiness, perishability, and versatility. We find that the effect holds for many foods, and specifically for those that are more perishable and less versatile.

The final section outlines the contributions of our work and ideas for further research. Briefly, we add to the price promotion and food literatures a fuller account of promotion-induced post-purchase behaviors and to consumer research a conceptualization of waste aversion as a situational factor that, for many types of food, can be triggered by something as common as a price deal and can influence behavior beyond purchase decisions. This advances our understanding of when and why waste aversion surfaces and affects decision-making. Our findings are also relevant to retailers and regulators thinking of capping or banning MUPs, and to marketing professionals looking to contribute on issues of sustainability. Finally, future studies can build on our research in different ways. For example, if one expands the standard definition of food waste to include overnutrition (Parfitt, Barthel, and Macnaughton 2010), then it makes sense to test whether the changes in consumption reported in our studies are acceptable from the perspective of people's wellbeing or, in fact, they are problematic.

BACKGROUND

Marketing Research on Price Promotions

Marketing scholars have a long-standing interest in price promotions. The decision of households to purchase a product on discount can be construed as a compromise between expected benefits and costs (Ailawadi, Neslin, and Gedenk 2001), where the former comprise monetary savings and sensations such as shopping enjoyment, and the latter include the hassles of searching, thinking, switching, and holding extra inventory. Importantly, studies show that different types of price promotions prompt different behaviors not only in the store but also in the home (Ailawadi et al. 2001; Lichtenstein, Netemeyer, and Burton 1995).

A common distinction is between SUP and MUP, and research confirms that the larger purchase quantities demanded by the latter indeed leads to larger promotional lifts (Foubert and Gijsbrechts 2007; Manning and Sprott 2007; Wansink, Kent, and Hoch 1998). For instance, Foubert and Gijsbrechts (2007) show that multi-unit deals boost spending as long as the minimum purchase quantity does not exceed a critical point. Similarly, Manning and Sprott (2007) find that purchase-quantity intentions are higher for multi-unit deals because the higher threshold relative to a single-unit deal drives shoppers to buy more than they otherwise would. This effect is explained by an anchoring process, where the quantity requirement influences people's purchase quantity decision (Wansink et al. 1998).

With respect to post-purchase behaviors, research suggests that households adjust to promotion-induced overbuying in two ways. First, they accelerate and/or increase their consumption (Ailawadi et al. 2007; Ailawadi and Neslin 1998; Chandon and Wansink 2002). Second, households store part or all of the extra quantities for future consumption. Indeed, post-promotion "dips" in sales are often interpreted as the consequence of shoppers stocking up during the promotional period (Macé and Neslin 2004). More direct evidence comes in the analysis of scanner panel data (Ailawadi et al. 2007), where a lower probability of a repeat purchase in the period following a promotional purchase suggests that households stored the product for future consumption.

In summary, to the extent that MUPs are more likely to prompt overbuying than SUPs, they are also more likely to prompt changes in consumption and storing. What remains unclear, however, is whether these are the only relevant post-purchase behaviors. Conceptually, it is possible for households to eat, stock, and discard more of the discounted foods they take home; yet, the literature does not contemplate the latter—it assumes that all food not consumed today is stored and consumed at some later point. This oversight likely stems from the fact that research on the post-purchase effects of price promotions mostly relies on scanner panel data (Hawkes 2009). Yet, if the objective is to clarify the relationship between price promotions and food waste, then one needs to study how households handle food in their homes.

Food Research on Waste

Over the past decade, household food waste has become an important topic among food scholars. The literature here tends to focus on the impact of demographic factors such as household size, age, employment status, and education level; psychographic factors including perceived behavioral control and personal norms; and food-management practices such as planning, cooking routines, and the treatment of leftovers (Boulet, Hoek, and Raven 2021; Schanes, Dobernig, and Gözet 2018). Perhaps unsurprising, two conclusions are that households anticipate higher food waste from larger purchases (Le Borgne, Sirieix, and Costa 2018; Petit, Lunardo, and Rickard 2020) and that households regularly purchasing too much food tend to waste more of it (Stancu, Haugaard, and Lähteenmäki 2016; Stefan et al. 2013).

Some studies examine factors external to the household such as retail infrastructure and sales tactics, including price promotions (Tsalis et al. 2021). Early insights into

the relationship between price promotions and household food waste draw mostly on people's own intuitions elicited through qualitative research methods. Households believe that in-store marketing "ploys" promoting savings through bulk purchases prompt them to waste food (Farr-Wharton, Foth, and Choi 2014; Graham-Rowe, Jessop, and Sparks 2014). In their framework, Boulet et al. (2021) list retail sales tactics as one of the most cited external causes of food waste; yet, Tsalis et al. (2021, 12) warn that several studies "consider price promotions to be a waste-promoting factor and consequently treat them as such in their studies, for example, when using the tendency to purchase multi-items as an indicator of food waste behavior."

The problem with intuitions is that they may be inaccurate. Accordingly, food scholars have sought greater clarity by examining the correlation between relevant purchase patterns (e.g., promotional buying) or traits (e.g., price consciousness) and food waste. Unfortunately, while some articles show that frequent promotional buyers tend to throw away more food (Fonseca 2013; Ponis et al. 2017), others show that households that identify as price conscious tend to throw away less food (Koivupuro et al. 2012; Williams et al. 2012). The findings appear inconclusive.

This inability to find a clear and consistent result may be due to the empirical approach. Purchase traits such as the tendency to buy on discount may be associated with other (unobserved) household characteristics, leading to correlations that misrepresent causal relationships. In our view, the food literature lacks studies that take purchases under different price promotion "conditions" as the starting point and document how foods are used in homes. In the next section, we report a large-scale field test that aims to address this limitation.

EVIDENCE FROM THE FIELD

Data Collection

We collaborated with GfK, the leading market research agency in the Netherlands, to collect data from a specially made questionnaire sent to households the week after their purchase of eight perishable foods—as informed by GfK's 10,000-household scanner panel data. Data collection took place over a period of 9 weeks among households shopping at Albert Heijn (AH), the largest Dutch supermarket retailer.

Product Selection. To guarantee statistical power, we focused on food categories that historically have a high incidence of waste: fresh bread, fruits, and vegetables (van Herpen et al. 2019a). From these categories, we chose foods that are (1) likely to be consumed or discarded within the period between purchase and receipt of the questionnaire (according to estimates from the Netherlands Nutrition Centre, these foods spoil on average within 1 week of purchase), (2) pre-packed, such that purchase quantity is set by the retailer, and (3) regularly offered on a SUP and a MUP. To comply with the last point, we received confidential access to AH's promotional calendar. Moreover, note that we focused on periodic (weekly) deals rather than deals on food close to its expiration date.[1] The final mix comprised eight foods: white grapes, cut vegetable mix, flat beans, kale, lettuce mix, vine tomatoes, bread loafs, and soft bread rolls.

Method. Data collection took place between weeks 2 and 10 of 2019. Figure 1 provides an overview. Promotions at AH run from Monday to Sunday and change weekly. The same deals are offered nationwide across all stores. Accordingly, on the Monday of each week, we visited an AH store to verify that the deals in the promotional calendar matched those actually on offer and to record each product's barcode. We then checked whether households in the GfK scanner panel purchased one or more of the foods from our mix by matching the barcodes scanned at home. Upon a match, we sent households an electronic questionnaire on the Friday of the week following their purchase (i.e., with a delay of 5–11 days) and asked them to complete it within 1 week.

In our data, therefore, the time between purchase and completion of the questionnaire ranged from 5 to 18 days.[2] To avoid overburdening respondents, the questionnaire focused on one food. That is, when a household purchased multiple foods from the mix during the same week, we sent a questionnaire on the food with the lowest number of total purchases across all sampled households. We did this to maximize observations for each food. Note that households could be surveyed multiple times across the data collection period.

AH's actual promotional activity across the 9 weeks varied slightly from the one outlined in the promotional calendar. While all foods in the mix were sold at RPs and on a MUP, only grapes, kale, and bread loafs were also sold on a SUP. Every MUP required households to purchase a minimum of two packages. For six foods, the deal was "buy one, get one." For grapes and soft bread rolls, the deal was "two for €3" (RP: €2) and "50% off on the second package," respectively.

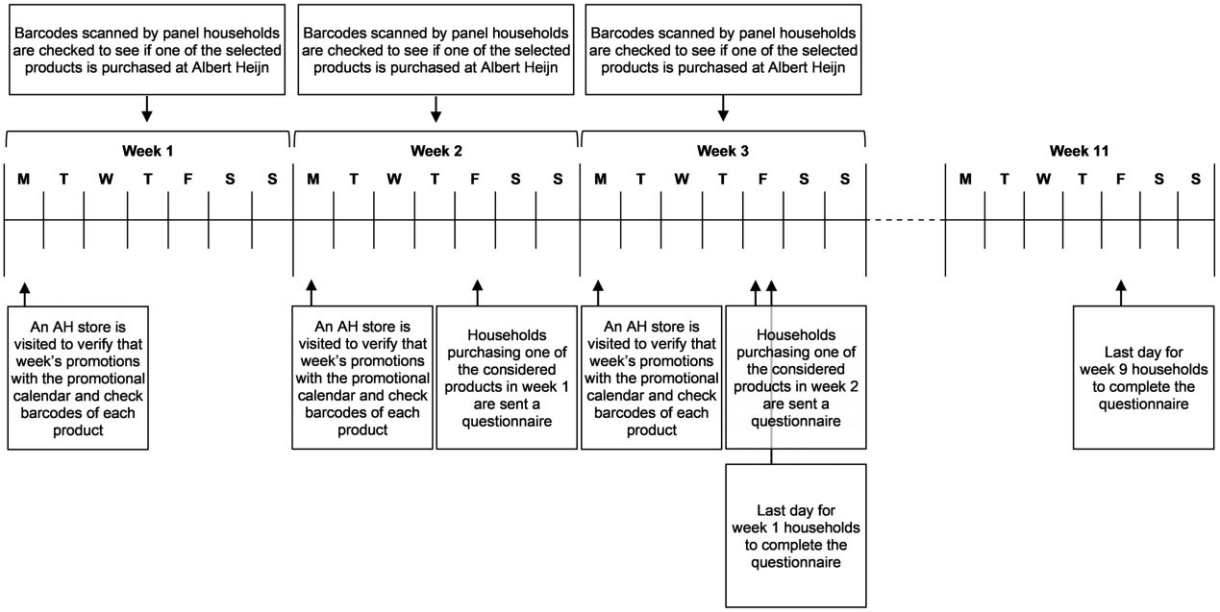
Questionnaire. The questionnaire sought to understand whether the food was consumed, stored for future

1 Periodic price promotions, which are typically advertised in a retailer's store flyers, are those often criticized for causing food waste. These deals are planned in advance as part of a broader promotional strategy and are not used to move expiring stock. This was confirmed by the sustainability manager of AH. For food close to its expiration date, AH uses separate price promotions.

2 GfK experienced an unexpected server error during one of the data collection weeks and the questionnaire reached households on the following Monday rather than Friday. Accordingly, in a few cases, households received the questionnaire 8–14 days and completed it 8–21 days after their purchases.

FIGURE 1

TIMELINE OF THE DATA COLLECTION PROCEDURE



Notes: AH = Albert Heijn. To avoid overburdening respondents, households received at most one questionnaire per week focusing on the food with the lowest number of total purchases across all sampled households.

consumption, or discarded (web appendix A). In the introduction, we reminded households about their purchase of the food at AH in the previous week, asked them whether they remembered this purchase and, if so, how many packages they bought at AH that week. We then asked the extent to which (1) the purchase was planned, (2) the food was purchased because of a favorable price, (3) the food was needed for a specific recipe or meal, and (4) the purchase was a routine one (7-point semantic differential scale).

In the main part of the questionnaire, households indicated whether they consumed the food, stored it for future consumption, or whether any of it was wasted. Our approach builds on van Herpen et al. (2019a), who show that asking about food wasted in the past week correlates strongly with direct measures such as collecting and weighing actual waste. Yet, self-reported measures of waste present two challenges. First, there is often confusion as to what "waste" means. To address this, we adopted the definition by the United Nations (UN) of "food that was originally meant for human consumption but for various reasons is removed from the human food chain" (United Nations Environment Programme [UNEP] 2021b). Thus, it includes all food purchased but ultimately not consumed, whether disposed of (in the general trash, a dedicated food waste container, or the compost heap) or fed to a pet or animal.[3] Accordingly, we explained to respondents that we focus on food purchased for human consumption that is not eaten and that by "not eaten" we mean "everything that may have happened to the product" including waste generated before, during, and after the preparation and consumption of a meal.

The second challenge with self-reported measures of waste is the possibility of underreporting due to social desirability concerns. While this issue may not be significant in our study because we focus on comparing households across price settings, we took several precautions. Following van Herpen et al. (2019b), we reminded households that not all food purchased is actually eaten. More important, rather than asking about waste directly, we adopted a three-step approach and asked (1) all households if they ate all of the food (1 = "nothing has been eaten" to 5 = "everything has been eaten"), (2) households that indicated not eating part or all of the food if it is still on stock (in the fridge, a fruit bowl, the freezer, etc.) or discarded, and (3) households that indicated discarding any of the food to estimate the quantity.

3 Of all the waste reported by households in our sample, 95% was disposed of in the general thrash or dedicated food waste container, 4% went to the compost heap, and 1% was fed to a pet or animal. Our results are virtually the same if we limit our definition to the trash and food waste container.

For the last step, we provided estimates that respondents could easily relate to van Herpen et al. (2019b). For example, for grapes the options were "less than a handful of grapes," "a handful of grapes," "about a quarter of a box of grapes," "about half a box of grapes," "about three-quarters of a box of grapes," "about one box of grapes," and "more than one box of grapes." We converted these estimates into numerical values based on information from AH and the Netherlands Nutrition Centre, with "less than a handful" equivalent to 0.0625 of a package, "a handful" to 0.125 of a package, and "more than one box" to 1.5 of a package. Households reported wasting more than one package in 10 instances. Setting waste at a level other than 1.5 packages does not affect our findings.

To conclude, the questionnaire asked households that indicated wasting part or all of the food to provide the main reasons for this (because it went off, it was past the date on the label, the amount purchased was more than needed, etc.) and households that indicated stocking part or all of the food for future consumption when they thought this would be used.

Sample. The response rate was 65.7% when the purchase was at the RP, 65.7% for a SUP, and 67.6% for a MUP, leading to 2,563 responses. The average time between receipt of the questionnaire and response was 1.3 days (median: 0 days). The average time between purchase and response is 10.5 days (median: 10 days).

We removed 5 responses because the household reported purchasing 0 (one response) or more than 10 (four responses) packages and 11 responses because the household reported wasting more than they actually purchased at AH in the week indicated in the questionnaire, leaving 2,547 responses by 1,646 unique households. Irrespective, including the omitted responses, did not affect the results of our analyses.

When households completed the questionnaire more than once (i.e., in more than 1 week), this was because they purchased more than one of the eight foods in the mix, they purchased the same food in different price settings, or they purchased the same food in the same price setting during multiple weeks. The first event is most frequent: households completed the questionnaire for an average of 1.34 foods. Of the 2,202 household-food combinations, the questionnaire was completed for a single price setting in 1,990 cases, for 2 in 200 cases, and for all 3 in 12 cases. Moreover, households completed the questionnaire twice for the same food-price setting combination in 84 cases, 3 times in 14 cases, and 4 times in 3 cases—all of which involved purchases at RPs.[4]

Finally, GfK provided demographic information for all participating households, including household size, income bracket, and age of the head of the household (in 10 groups, 1 = 24 years old or younger to 10 = 75 years old or more). Table 1 reports the number of responses and descriptive statistics of these demographics by price setting. We observe differences primarily for household size, with more purchases by larger households in the MUP setting than in the SUP or RP setting. To control for this, we include the demographics in our analyses as covariates.

Household Scanner Panel Data. In addition to the survey data, we received access to GfK's household scanner panel data. These data comprise the complete purchase records (stores visited, items purchased with quantities, and prices paid) of the households that participated in the questionnaire for the period January 2018 to June 2019. This provides insight into purchase patterns in the period before and after data collection.

Model-Free Evidence

We report model-free evidence for the key measures here and relegate further descriptive statistics to web appendix B. First, as figure 2 shows, while purchases on a MUP comprised larger quantities than did purchases at RPs ($t(2{,}082) = 25.565$, $p < .001$), this is not the case for purchases on a SUP ($p = .51$).[5] To understand this result, we take households that purchased on a MUP and compare their purchase quantity to their purchase quantities at RPs in the year prior to data collection (as reported in the household purchase data). This comparison paints a similar picture ($M_{MUP-usual} = 0.78$, $t(555) = 21.129$, $p < .001$),[6] which confirms the finding in the literature that purchase quantities in response to MUPs are larger than usual. Although some previous work shows that SUPs also prompt larger purchases (Foubert and Gijsbrechts 2007), this is not the case in our data, presumably because we focus on perishables.

Next, we check reported food waste. To draw meaningful comparisons, we express waste in a similar unit for all foods: number of packages. Another common measure is the weight of food that is wasted (in grams). Figure 3 reports both measures. Interestingly, these initial comparisons suggest that foods purchased on a MUP were not wasted more than foods purchased at RPs. In fact, although the number of packages purchased on a MUP was logically higher, the number of packages ($t(2{,}082) = 2.926$, $p < .01$)

4 The total number of household-food-price setting combinations is $1{,}990 \times 1 + 200 \times 2 + 12 \times 3 = 2{,}426$. The number of observations contributed by households that completed the questionnaire multiple times for a given food-price setting combination increases this total to 2,547 observations ($2{,}426 + 84 \times (2 - 1) + 14 \times (3 - 1) + 3 \times (4 - 1) = 2{,}547$).

5 As noted, the survey data combine independent observations and repeated measures. As such, standard tests are indicative but may not fully apply. For our formal analyses, we use random effects at the household level.

6 The degrees of freedom for this contrast are lower than N (1,111) − 1 because not all households that purchased a food on a MUP were part of the panel or purchased the same food in the absence of a promotion at AH in the year prior to data collection.

TABLE 1

DEMOGRAPHICS OF HOUSEHOLDS IN THE SAMPLE

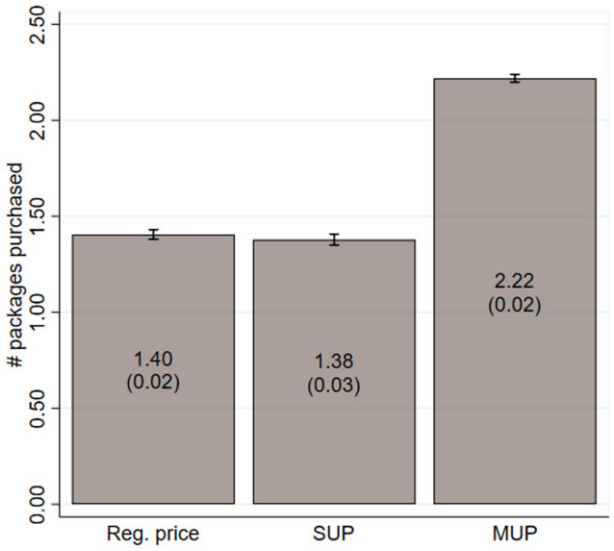
	RP		SUP		MUP		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Household size	2.37	1.18	2.43	1.28	2.65	1.29	2.50	1.25
Age (1–10)[a]	6.89	2.22	6.90	2.24	6.88	2.17	6.89	2.20
Below middle income (%)	30.0		32.9		28.7		30.0	
Middle income (%)	34.0		34.6		37.0		35.3	
Above middle income (%)	36.1		32.5		34.3		34.7	
N	973		463		1,111		2,547	

Notes: Descriptive statistics are computed over all observations. Households contributed multiple observations when they purchased the food multiple times during the data collection period and/or purchased more than one of the foods in the mix (maximum 1 observation per week).

[a]1 = 24 y.o. (year old) or younger, 2 = 25–29 y.o., 3 = 30–34 y.o., 4 = 35–39 y.o., 5 = 40–44 y.o., 6 = 45–49 y.o., 7 = 50–54 y.o., 8 = 55–64 y.o., 9 = 65–74 y.o., and 10 = 75 y.o. or older.

FIGURE 2

PACKAGES PURCHASED



Note: Error bars = ±1 SEs.

and weight ($t(2,082) = 2.184$, $p = .03$) wasted were less. We also observe less reported waste from purchases on a SUP relative to purchases at RPs, though the difference is statistically significant for number of packages ($t(1,434) = 2.228$, $p < .05$) but not weight ($p = .24$).

What caused this waste? In about 45% of cases, households indicated the food "went off," "did not look good anymore," or "was past the date on the label" (RP: 48%, SUP: 47%, MUP: 39%; $p = .44$). Again, although the number of packages purchased on a MUP was larger, this was not a reason to waste: households indicated that the amount purchased was more than needed in only about 20% of cases, and this percentage does not vary significantly across price settings (RP: 19%, SUP: 25%, MUP: 21%; $p = .70$). No other reason shows significant differences across price settings (all $p's > .42$).

Fourth, we examine how households used the foods that they did not waste. Figure 4A shows that consumption is higher for purchases on a MUP than for purchases at RPs ($t(2,082) = 15.903$, $p < .001$). Conversely, consumption is lower for purchases on a SUP than for purchases at RPs ($t(1,434) = 2.040$, $p = .04$).[7] In terms of storing, freezing is a valid and common option to avoid waste for all foods in our mix except grapes and lettuce. Figure 4B shows that the number of packages frozen is higher for purchases on a MUP ($t(2,082) = 8.059$, $p < .001$) or a SUP ($t(1,434) = 2.631$, $p < .01$) than for purchases at RPs.

Finally, households mostly indicated that they planned to consume leftovers within the next week (64% of cases) or month (27%). Compared to purchases at RPs, leftovers of foods purchased on a MUP were planned to be consumed in the next month more often (MUP: 32% vs. RP: 16%; $\chi^2(1) = 12.497$, $p < .001$). In only 0.8% of the purchases on a MUP with leftovers, households indicated that they probably would not eat the remainder. This percentage was marginally lower than for purchases at RPs (3%; $\chi^2(1) = 3.443$, $p = .06$). There was no significant difference in responses to this question between purchases on a SUP and at RPs ($p = .76$).

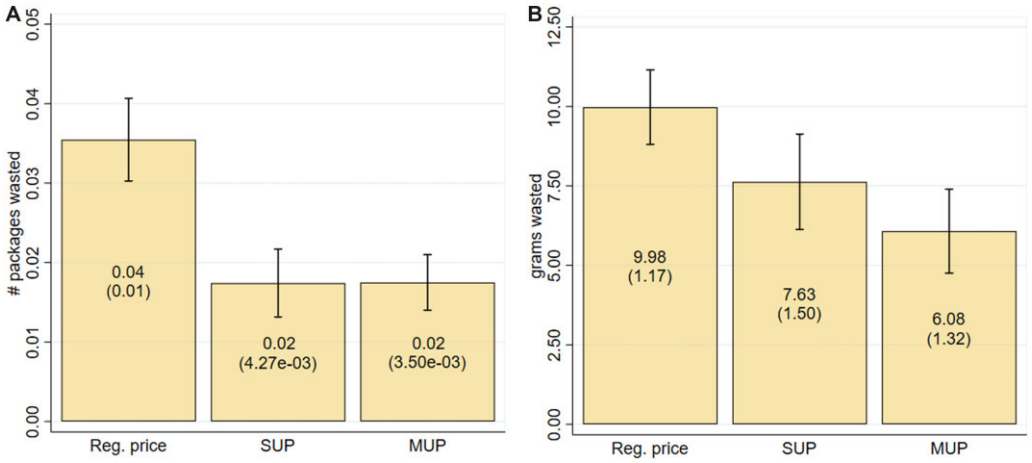
Main Analysis of Household Food Waste

To better understand household waste behavior, we need to separate the effect of price promotions from those of

7 To compute the number of packages eaten, we coded the answer option "nothing has been eaten" as 0% of the packages purchased, "almost nothing has been eaten" as 10%, "a part has been eaten" as 50%, "almost everything has been eaten" as 90%, and "everything has been eaten" as 100%. For example, the number of packages eaten for a household that purchased two packages and indicated that "almost everything has been eaten" is computed as 0.9 × 2 = 1.8. The results do not change substantially when we apply different codes to the answer options.

FIGURE 3

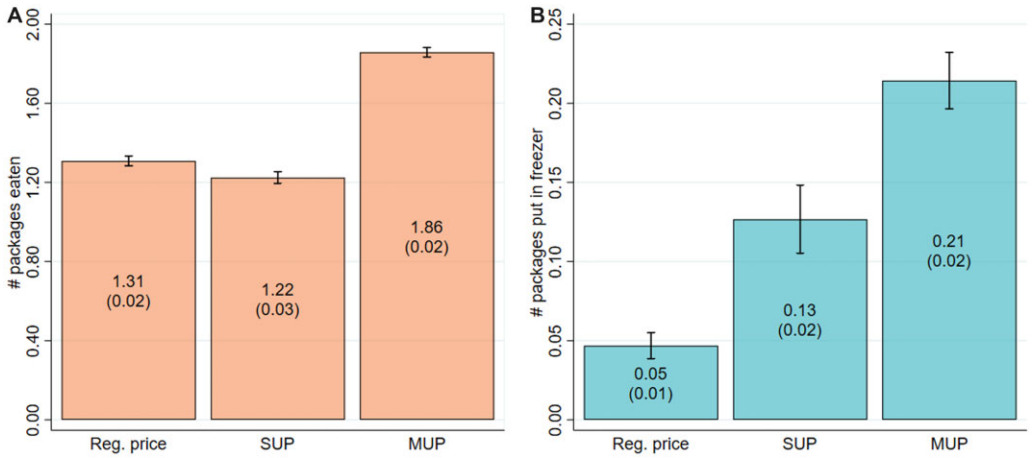
PACKAGES AND WEIGHT WASTED



Notes: (A) Packages. (B) Weight. Error bars = ±1 SEs.

FIGURE 4

CONSUMPTION AND FREEZING



Notes: (A) Packages eaten. (B) Packages put in freezer. Error bars = ±1 SEs. Descriptive statistics for packages put in freezer exclude grapes and lettuce.

other factors such as household demographics. Indeed, households that purchase on a deal may differ from those that do not and may naturally waste less. Because not all households reported wasting foods, and consistent with previous efforts to capture food waste (Qi and Roe 2017), we use a Tobit model. We include dummies for SUP and MUP (with purchases at RPs as the reference). We also include household size, dummies for below and above middle income (with middle income as the reference), and age as covariates. Finally, we account for differences in waste behavior across the mix by adding product fixed effects, and for any remaining (unobserved) heterogeneity across households via a random-effects specification.

Table 2 reports estimates for models with number of packages or weight wasted as the dependent variable. Consistent with the model-free evidence, these estimates indicate that SUPs and MUPs do not increase household food waste. In fact, our analysis shows that foods sold on a

TABLE 2

RANDOM EFFECTS TOBIT AMOUNT OF FOOD WASTED

	Y = # packages wasted		Y = Weight of food wasted in grams	
	b (se)	z	b (se)	z
Promotion type				
SUP	−0.031 (0.061)	−0.503	−9.319 (19.315)	−0.482
MUP	−0.156 (0.044)	−3.513***	−47.175 (14.084)	−3.350***
Covariates				
Household size	0.020 (0.018)	1.121	5.033 (5.755)	0.875
Below middle income	−0.014 (0.056)	−0.251	−7.917 (17.956)	−0.441
Above middle income	0.038 (0.049)	0.791	14.176 (15.480)	0.916
Age	−0.045 (0.010)	−4.616***	−13.826 (3.113)	−4.442***
Constant	−0.445 (0.107)	−4.155***	−145.232 (34.315)	−4.232***
Product fixed effects	Included		Included	
Log likelihood	−682.604		−2,213.964	
χ^2 (df)	46.858 (6)***,[a]		44.028 (6)***,[a]	
N	2,547		2,547	

[a]Likelihood ratio test with log likelihood of a model with only product fixed effects.
†$p < .10$ (two sided).
*$p < .05$ (two sided).
**$p < .01$ (two sided).
***$p < .001$ (two sided).

MUP are wasted less in terms of packages ($b = -0.156$, $p < .001$) and weight ($b = -47.175$, $p < .001$) than foods sold at RPs. In contrast, the difference in reported food waste between purchases on a SUP and purchases at RPs is no longer significant (number of packages: $b = -0.031$, $p = .62$; weight: $b = -9.319$, $p = .63$). A reduced specification with only product fixed effects as covariates suggests that this discrepancy occurs primarily from adding said covariates (which account for baseline differences in food waste across the limited number of foods offered on a SUP during the data collection period relative to the full mix sold at RPs).

As for the covariates, the effects of household size and income are not significant in either model (all $ps > .26$). In line with other research on food waste (Secondi, Principato, and Laureti 2015), the amount of food waste is lower when the head of the household is older (number of packages: $b = -0.045$, $p < .001$; weight: $b = -13.826$, $p < .001$).

In summary, the model results indicate no difference in reported food waste between purchases on a SUP and at RPs, but lower reported food waste for purchases on a MUP. The robustness checks presented in web appendix C further show that these effects are not driven by any one food and are similar when we count only a household's response to the first questionnaire received (i.e., they are independent of "testing effects").

If Not Wasted, Then What?

The model-free evidence suggests that households that purchased on a deal adjusted their consumption and/or froze the food for future consumption. We now study these post-purchase behaviors more formally. First, we regress the number of packages eaten on dummies for SUP and MUP and on the other variables included in the household food waste model. In line with the model-free evidence, the estimates in table 3 show that consumption was higher for foods purchased on a MUP than for foods purchased at RPs ($b = 0.545$, $p < .001$). This was not the case for foods purchased on a SUP after controlling for other factors ($p = .61$). Second, we re-estimate the model with packages frozen as the dependent variable. Because not all households reported freezing something, we again use a Tobit model. In line with the model-free evidence, table 3 shows that more packages purchased on a MUP were frozen than packages purchased at RPs ($b = 0.937$, $p < .001$). This effect is not significant in the case of packages purchased on a SUP after controlling for other factors ($p = 1.00$).

Of course, it is possible that packages frozen were not actually consumed. While we cannot formally rule this out, households overwhelmingly reported planning to consume the remainder within the next week or month. Moreover, an analysis of the household purchase data in the period after completing the questionnaire (web appendix C) shows that households reporting they will consume the frozen amount during the next week or month purchased less from the same category during the next week or month than did other households, suggesting that they "dug" into their freezer supply. Similarly, in some cases households indicated that they still had (part of) the food in the fridge or in some place other than the freezer. As we show in web appendix C, further analysis of the survey data and an analysis of the household purchase data in the period after

TABLE 3

RANDOM EFFECTS MODELS CONSUMPTION AND FREEZING

	Y = # packages eaten (RE regression)		Y = # packages in freezer (RE Tobit)	
	b (se)	*z*	*b* (se)	*z*
Promotion type				
SUP	−0.024 (0.047)	−0.518	0.001 (0.183)	0.004
MUP	0.545 (0.033)	16.626***	0.937 (0.134)	6.973***
Covariates				
Household size	0.090 (0.015)	6.181***	−0.016 (0.054)	−0.301
Below middle income	0.057 (0.042)	1.360	0.308 (0.154)	1.999*
Above middle income	0.049 (0.039)	1.253	0.169 (0.142)	1.191
Age	0.021 (0.008)	2.672**	−0.047 (0.028)	−1.658†
Constant	0.709 (0.086)	8.267***	−1.101 (0.315)	−3.494***
Product fixed effects	Included		Included	
Log likelihood	−2,789.964		−919.835	
χ^2 (df)	389.245 (6)***,[a]		73.055 (6)***,[a]	
N	2,547		2,547	

[a]Likelihood ratio test with log likelihood of a model with only product fixed effects.
†$p < .10$ (two sided).
*$p < .05$ (two sided).
**$p < .01$ (two sided).
***$p < .001$ (two sided).

completing the questionnaire suggest that foods stored outside of the freezer likely ended up eaten and/or frozen rather than wasted.

Potential Explanations

A simple explanation for the finding that food purchased on a MUP was wasted less than food purchased at RPs is that households taking advantage of deals, and in particular MUPs, differ from others on some characteristic that carries through to post-purchase behaviors. While our analyses include a rich set of demographics as covariates, households may differ on other dimensions. In particular, households attracted to price promotions may be inherently more careful not to waste money and other resources, including food. To account for this, we approached the sampled households again after the 9-week data collection and asked them to complete a follow-up questionnaire on frugality and their general attitude to preventing food waste. To measure frugality, we used five of the eight items in the scale developed by Lastovicka et al. (1999): "I believe in being careful in how I spend my money," "I discipline myself to get the most from my money," "There are many things that are normally thrown away that are still quite useful," "Making better use of my resources makes me feel good," and "If you take good care of your possessions, you will definitely save money in the long run" (all 1 = "completely disagree" to 7 = "completely agree;" α = .77). We measured general attitude to preventing food waste with the statement "I pay attention to prevent throwing away food" (1 = "completely disagree" to 7 = "completely agree").

TABLE 4

DESCRIPTIVE STATISTICS, ATTITUDINAL VARIABLES

	Regular price		SUP		MUP		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Frugality	5.79	0.63	5.82	0.63	5.86	0.66	5.83	0.64
Food waste attitude	5.91	0.99	6.05	0.84	6.02	0.90	5.98	0.93
N	848		399		967		2,214	

Notes: Both variables are measured on a 7-point scale. Descriptive statistics are computed over all observations. Households can contribute several observations when they purchase the food multiple times during the data collection period and/or purchase more than one of the eight selected foods (maximum 1 observation per week).

Eighty-six percent (1,415) of the households that participated in the main questionnaire completed this follow-up questionnaire, such that we have these additional measures for 2,214, or 87%, of the 2,547 observations. Table 4 provides descriptive statistics for these additional measures and table 5 reports the estimates of our models including the measures as additional covariates. The effect of frugality on reported waste is not significant for packages or weight wasted (both $p's > .17$), but the general attitude to food waste has a strong negative effect (packages: b = −0.162, $p < .001$; weight: b = −52.631, $p < .001$). This suggests that households with a stronger attitude to preventing food waste also wasted less, which provides convergent validity for our measure of food waste. The parameter estimate of the MUP dummy remains negative and significant (packages: $b = -0.131$, $p < .01$; weight: $b = -43.664$, $p < .01$), while the parameter estimate of the

TABLE 5

RANDOM EFFECTS TOBIT AMOUNT OF FOOD WASTED INCLUDING ATTITUDINAL VARIABLES AS ADDITIONAL COVARIATES

	Y = # packages wasted		Y = Weight wasted (grams)	
	b (se)	*z*	*b* (se)	*z*
Promotion type				
SUP	−0.011 (0.067)	−0.161	−6.055 (22.216)	−0.273
MUP	−0.131 (0.047)	−2.761**	−43.664 (15.766)	−2.769**
Covariates				
Household size	−0.006 (0.020)	−0.295	−1.337 (6.667)	−0.200
Below middle income	−0.026 (0.061)	−0.427	−10.759 (20.387)	−0.528
Above middle income	0.062 (0.053)	1.185	20.910 (17.643)	1.185
Age	−0.029 (0.011)	−2.748**	−8.842 (3.561)	−2.483*
Frugality	0.052 (0.038)	1.361	16.329 (12.807)	1.275
Food waste attitude	−0.162 (0.025)	−6.440***	−52.631 (8.463)	−6.219***
Constant	0.136 (0.232)	0.588	33.068 (77.398)	0.427
Product fixed effects	Included		Included	
Log likelihood	−557.086		−1,865.496	
χ^2 (df)	86.527 (8)***,[a]		81.682 (8)***,[a]	
N	2,214		2,214	

[a]Likelihood ratio test with log likelihood of a model with only product fixed effects.
†$p < .10$ (two sided).
*$p < .05$ (two sided).
**$p < .01$ (two sided).
***$p < .001$ (two sided).

SUP dummy remains not significant (both ps $> .79$). That is, holding frugality and general attitude to preventing food waste constant, we continue to find that foods purchased on a MUP are wasted less than foods purchased at RPs.

A different explanation is that, rather than appealing disproportionately to specific households, price promotions change the way households behave after their purchases. We already showed that the minimum purchase quantity demanded by MUPs drove households to buy more than households that purchased at RPs. It is possible, then, that overbuying prompts households to mitigate waste. We can test this idea by checking whether the effect of buying on a MUP on waste is attenuated when, for any given household, the corresponding purchase quantity matches the usual purchase quantity at RP. To do this, we compute usual purchase quantities as the average (weekly) purchase quantities for transactions at RPs at the retailer in the year prior to the data collection period (across all weeks in which households purchased the food). We observe that households that purchased at RPs during the 9 weeks of our study took home quantities equal to or lower than their usual quantity in 54.0% of cases. Households that made purchases on a SUP or MUP did so in 27.9% and only 10.7% of cases, respectively.[8]

Table 6 shows the results of a model of household waste that allows for differences between these two situations. The covariates are similar to the ones previously included (including the two attitudinal variables added above). The estimates for the SUP dummy, and the interaction of that dummy with the dummy for purchasing the usual quantity or less, are not significant, and neither is the main effect of the latter dummy (all ps $> .16$). Yet, the estimates show a significant effect for the MUP dummy (packages: $b = -0.195$, $p < .01$; weight: $b = -60.266$, $p < .01$), and the interaction of that dummy with the dummy for purchasing the usual quantity or less (packages: $b = 0.276$, $p = .02$; weight: $b = 87.960$, $p = .02$).

Because the quantity purchased on a MUP is more often larger than usual, the relevant estimate to understand how food waste changes in the event of overbuying is the difference between (1) food waste for purchases on a MUP when the quantity is larger than usual versus food waste for purchases at RPs when the quantity is not larger than usual and (2) food waste for purchases on a MUP when the quantity is not larger than usual versus food waste for purchases at RPs when the quantity is not larger than usual. Using the estimates of the model of packages wasted, the first comparison is $-0.195 - (-0.090) = -0.106$ ($p = .08$) and the second is $(-0.090 + -0.195 + 0.276) - (-0.090) = 0.081$ ($p = .42$). For the model of weight wasted, the first comparison is $-60.266 - (-18.443) = -41.823$ ($p = .04$) and the second is $(-18.443 + -60.266 + 87.960) - (-18.443) = 27.694$ ($p = .40$). This shows that the effect of MUPs on food waste indeed depends on the quantity purchased. When the purchase quantity is larger than usual (i.e., in the

8 Because some households only joined the panel in the year of data collection, the number of observations for which this (backward-looking) variable is available is lower than for the variables used in the previous analysis (2,138 vs. 2,214). For households that were part of the panel but did not purchase the same food in the year prior to data collection, the usual quantity is set to zero.

TABLE 6

RANDOM EFFECTS TOBIT AMOUNT OF FOOD WASTED INCLUDING INTERACTIONS WITH THE QUANTITY-AS-USUAL DUMMY

	Y = # packages wasted		Y = Weight wasted (grams)	
	b (se)	*z*	*b* (se)	*z*
Promotion type + interactions with the quantity-as-usual dummy				
SUP	−0.042 (0.088)	−0.479	−10.883 (29.215)	−0.373
SUP × quantity-as-usual dummy	0.018 (0.133)	0.134	−2.825 (43.926)	−0.064
MUP	−0.195 (0.061)	−3.181**	−60.266 (20.597)	−2.926**
MUP × quantity-as-usual dummy	0.276 (0.117)	2.359*	87.960 (38.629)	2.277*
Quantity-as-usual dummy	−0.090 (0.064)	−1.396	−18.443 (21.411)	−0.861
Covariates				
Household size	−0.007 (0.021)	−0.324	−1.554 (7.050)	−0.220
Below middle income	−0.015 (0.064)	−0.241	−7.693 (21.321)	−0.361
Above middle income	0.078 (0.056)	1.391	25.674 (18.608)	1.380
Age	−0.028 (0.011)	−2.527*	−8.429 (3.739)	−2.255*
Frugality	0.059 (0.040)	1.495	18.916 (13.287)	1.424
Food waste attitude	−0.168 (0.026)	−6.392***	−54.741 (8.804)	−6.218***
Constant	0.128 (0.242)	0.531	25.444 (80.765)	0.315
Product fixed effects	Included		Included	
Log likelihood	−528.450		−1,754.463	
χ^2 (df)	87.319 (11)***[a]		82.537 (11)***[a]	
N	2,138[b]		2,138[b]	

[a]Likelihood ratio test with log likelihood of a model with only product fixed effects.

[b]The "quantity-as-usual" dummy is computed across the year prior to data collection. Because some households only joined the panel in the year of the data collection, the number of observations for this analysis is lower than the number of observations for the previous analysis.

†$p < .10$ (two sided).

*$p < .05$ (two sided).

**$p < .01$ (two sided).

***$p < .001$ (two sided).

event of overbuying), foods sold on a MUP are associated with less waste than foods sold at RPs. When the quantity purchased is not larger than usual, they are not.

Analyses of households' consumption and freezing behavior show similar results: the effect for MUPs is most pronounced in the context of overbuying, albeit the effect does not reach significance for freezing (web appendix D).

Overall, our analyses show that MUPs reduce food waste when the associated purchase quantity is larger than usual for households. Promotion-induced overbuying appears to act as a trigger that encourages consumption and freezing, but the underlying psychological process is unclear. To that end, the next section describes a theory that explains this finding and reports one experiment that tests this framework and another that tests the generalizability of the link between MUPs and FWC—our proposed mediator.

A THEORY OF WASTE PREVENTION

Despite the popular notion that we live in a throwaway society, there is ample evidence that wasting is not a carefree act. People shun waste not only to avoid squandering money (Arkes 1996; Arkes and Blumer 1985; Okada 2006), but also because they dislike unused utility in a purchase (Bolton and Alba 2012). In fact, the mere anticipation of waste can be sufficient to change behavior, even in directions that are self-defeating. For example, waste aversion makes consumers reluctant to replace possessions they think are underutilized (Arkes 1996; Cripps and Meyer 1994; Haws et al. 2012; Okada 2006), it thwarts downsizing initiatives (Ross, Meloy, and Bolton 2021), and it motivates recycling efforts (Sun and Trudel 2017), but it also leads consumers to spend more by purchasing items individually rather than in a bundle if doing so is expected to reduce waste (Bolton and Alba 2012).

Closer to our context, Bolton and Alba (2012, 379) speculate that wasting food is especially aversive because "it represents a particularly acute form of deprivation (i.e., hunger) and/or rises to the level of immoral or sinful behavior." Scholars in marketing (Raghunathan and Chandrasekaran 2020) and food research (Le Borgne et al. 2021) have even argued that consumers' concern for food waste should be treated independently of general waste aversion because food is indispensable for survival. As such, they developed and applied alternative scales to capture trait aversion to food waste. For example, Le Borgne et al. (2021) show that people high in concern for food waste are more likely to adopt routines to reduce scraps, including ways to prolong shelf life.

At the same time, however, one can envision situations where the purchase context triggers a concern for waste that is independent of people's own dispositions. Arkes (1996) shows that consumers avoid making a purchase that would benefit them when they turned it down earlier at a

more attractive price. Okada (2006) shows that consumers are more likely to forego purchasing a next-generation product if it improves the current version primarily on existing features. In both cases, the desire not to appear wasteful arises contextually (a past inaction and the type of improvement, respectively). However, these articles do not concern food and, importantly, do not examine the possibilities that price promotion is itself a trigger and waste aversion impacts behavior beyond purchase decisions.

We build on the findings of the field study to propose that promotion-induced overbuying, which is naturally associated with MUPs because of the larger purchase quantities demanded by this type of deals, makes consumers temporarily mindful of the possibility of wasting food, and that this in turn encourages waste prevention in the home. While this idea is broadly consistent with research indicating that people anticipate wasting more food from larger purchases (Le Borgne et al. 2018; Petit et al. 2020), there is no direct evidence of this relation or its effect on consumption and freezing. Indeed, the marketing literature on price promotion does not contemplate the causes of food waste for the simple reason that it does not contemplate waste as a post-purchase behavior.

With this in mind, we hypothesize that, relative to purchases at RPs, purchases on a MUP heighten FWC and, in turn, increase waste prevention in the form of accelerated and increased consumption and more freezing. Relative to purchases at RPs, we do not expect purchases on a SUP to exhibit this effect. We conducted two experiments to test our theory and its generalizability. Briefly, in experiment 1, we examine whether the effect of a MUP on consumption and freezing is driven by heightened concerns about food waste. Then, in experiment 2 we test whether the link between MUPs and FWC generalizes across 96 foods varying in convenience, healthiness, perishability, and versatility—four properties that are prevalent in price promotion research, pertinent to the study of food waste, and meaningful to retailers.

Experiment 1

Design and Measures. We assigned 192 residents of the Netherlands recruited via Prolific (M_{age} = 29.50 years, 34.9% female) to an RP, SUP, or MUP condition. They read the following story regarding the purchase of pre-cut vegetable mix and then answered several questions. The story was accompanied by a picture of the food and, in the two conditions with a price promotion, a banner displaying the corresponding deal (web appendix E). The text in square brackets refers to these conditions:

> "Imagine the following situation. You go to the supermarket to do grocery shopping for the next few days. You buy ingredients for multiple meals. You plan to buy, among others, a pack of pre-cut vegetable mix of 400 grams to put in a pasta sauce. You arrive at the shelf with the pre-cut vegetables [and see that the supermarket has a price promotion for this product: a discount of 50%/two for the price of one] and buy this pack of 400 grams [this pack of 400 grams/two packs of 400 grams each]. According to the date label, it can be kept for four days."

After reading the scenario, participants reported FWC on three 100-point slider scales: "How concerned would you feel that some of the pre-cut vegetable mix may be wasted?" (0 = "not concerned at all" to 100 = "extremely concerned"), "How worried would you be that some of the pre-cut vegetable mix might go to waste?" (0 = "not worried at all" to 100 = "extremely worried"), and "How uneasy would you feel about the possibility that some of the pre-cut vegetable mix ends up being wasted?" (0 = "not uneasy at all" to 100 = "extremely uneasy"). These items were averaged into an index of FWC (α = .86).

Second, participants rated the likelihood they would freeze (part of) the pre-cut vegetables once they unpacked their groceries (0 = "very unlikely" to 100 = "very likely"). They were then told that today they intended to cook a meal that did not include pre-cut vegetables and asked whether they would eat the pasta meal with pre-cut vegetables instead (0 = "I would adjust my plan and use the pre-cut vegetable mix today" to 100 = "I would stick to my plan and not use the pre-cut vegetable mix today," reversely coded). This measure reflects accelerated consumption. Third, to capture increased consumption participants rated how likely they were to use part of the pre-cut vegetables as additional ingredients in a tomato soup that they also planned to prepare (0 = "very unlikely" to 100 = "very likely").

Finally, to gauge attention participants dragged a slider scale all the way to the right. They were further asked to indicate the food in the scenario and if a price promotion was offered (and its type). All participants passed the attention check, they all recalled the food, and 97.4% recalled the presence and type of price promotion.

Results. Table 7 reports the descriptive statistics. To start, we run separate one-way ANOVAs on each waste-preventing behavior and find that freezing ($F(2, 189) = 21.817$, $p < .001$, $\eta_p^2 = .188$), accelerated consumption ($F(2, 189) = 8.652$, $p < .001$, $\eta_p^2 = .084$), and increased consumption ($F(2, 189) = 6.326$, $p < .01$, $\eta_p^2 = .063$) differ significantly across conditions. Compared to participants in the RP condition, participants in the MUP condition expressed a higher likelihood to freeze (M_{MUP} = 62.73 vs. M_{RP} = 25.83; $t(189) = 6.236$, $p < .001$), accelerate consumption (M_{MUP} = 65.76 vs. M_{RP} = 44.23; $t(189) = 4.134$, $p < .001$), and increase consumption (M_{MUP} = 69.94 vs. M_{RP} = 51.16; $t(189) = 3.408$, $p < .001$). We find a similar effect when comparing the SUP and RP conditions on accelerated consumption (M_{SUP} = 57.00; $t(189) = 2.470$, $p = .01$), but not on

TABLE 7

DESCRIPTIVE STATISTICS, EXPERIMENT 1

	Regular price	SUP	MUP
Freezing	25.83 (3.72)	31.49 (4.29)	62.73 (4.66)
Accelerated consumption	44.23 (3.99)	57.00 (3.51)	65.76 (3.48)
Increased consumption	51.16 (4.22)	55.65 (3.98)	69.94 (3.38)
Food waste concerns	34.65 (3.51)	30.90 (2.80)	47.81 (3.00)

Note: All variables measured on 100-point slider scales.

freezing ($M_{SUP} = 31.49$, $p = .34$) or increased consumption ($M_{SUP} = 55.65$, $p = .41$). Moreover, we find that participants in the MUP condition reported a greater likelihood to freeze ($t(189) = 6.236$, $p < .001$), increase consumption ($t(189) = 2.603$, $p < .01$), and (marginally) accelerate consumption ($t(189) = 1.689$, $p = .09$) than participants in the SUP condition.

At the same time, an additional ANOVA shows an effect on FWC: $F(2, 189) = 8.08$, $p < .001$, $\eta_p^2 = .079$. Specifically, FWC is higher in the MUP condition ($M_{MUP} = 47.81$) than in the SUP ($M_{SUP} = 30.90$, $t(189) = 3.836$, $p < .001$) or RP ($M_{RP} = 34.65$, $t(189) = 2.976$, $p < .01$) conditions, but does not differ across these last two conditions ($p = .39$).

To test whether FWC mediates the effect of a MUP on waste prevention, we conduct three multicategorical mediation analyses (one for each waste-preventing behavior) using PROCESS model 4 in R, with 5,000 bootstrap samples (Hayes and Preacher 2014). The model includes dummy variables for the SUP and MUP conditions, and FWC as the mediator. We test indirect effects using 95% confidence intervals, and if these include zero, we also check the 90% confidence interval for potential marginal effects using the same bootstrap samples. Specifically, we conduct the analyses adjusting the confidence interval but fixing the start value (seed) for generating the bootstrap samples.

Tables 8 and 9 show the estimates of the mediation analyses, as well as the indirect effects and their confidence intervals. As expected, we find a significant indirect effect through FWC for the difference between the MUP and RP conditions on all three behaviors (freezing: effect = 3.676, 95% CI = [0.637; 8.111]; accelerated consumption: effect = 3.989, 95% CI = [1.042; 7.703]; and increased consumption: effect = 4.370, 95% CI = [1.1246; 8.460]). In contrast, the indirect effect for the difference between the SUP and RP conditions is not significant for any behavior (90% CI includes zero). Significant direct effects for the difference between the MUP and RP conditions persist for all behaviors, which establishes partial mediation.

Discussion. Experiment 1 shows that, relative to purchasing at RPs, purchasing on a MUP heightens concerns about food waste and, in turn, increases waste prevention by means of accelerated and increased consumption and more freezing.

One limitation is that FWC was elicited before the waste-preventing behaviors, possibly causing a demand effect. To address this concern, we conducted a follow-up experiment (supplementary experiment 1, web appendix F) in which we omitted the questions related to FWC. The results of this additional test with respect to consumption and freezing mirror those observed in experiment 1.

Moreover, we conducted another experiment (supplementary experiment 2, web appendix F) to separate our theory from other plausible accounts in the literature. First, Chandon and Wansink (2002) suggest that promotion-induced overbuying increases product salience in the home, which in turn increases consumption. Second, despite the fact that our stimulus specified the expiration date, participants may have inferred that perishable food is less fresh or of a lower quality overall when offered on a deal (Shiv, Carmon, and Ariely 2005) and, in turn, adjusted consumption and freezing. Accordingly, we replicated experiment 1 adding measures of salience, freshness, and overall quality. We again find that FWC mediates the effect of MUP relative to RP on accelerated consumption, increased consumption, and freezing. In addition, salience mediates the effect on each consumption measure but not on freezing, while freshness and overall quality play no such role.

Experiment 2

The goal of experiment 2 was to test the generalizability of the relationship between MUPs and FWC across different types of food. We see this as an important step to understand the extent to which the findings of the field study and experiment 1 carry consequences for the way supermarket retailers and policy makers view price promotions beyond the foods tested to this point. For example, it is important to understand if the effect extends to foods that are less healthy, in which case increasing consumption may be problematic from the perspective of people's wellbeing.

Product Selection. Given our objective, the choice of foods was guided by four food properties that are prevalent in price promotion research (Ailawadi and Neslin 1998; Chandon and Wansink 2002; Wansink and Deshpande 1994), pertinent to the study of food waste, and meaningful to retailers: (1) convenience—that is, the food is ready to eat or requires preparation, (2) healthiness, (3) perishability, and (4) versatility—that is, the food can be consumed on many different occasions and settings or integrated into different meals. Focusing on properties that are common to various foods rather than on specific foods ensures that we can later draw meaningful comparisons.

TABLE 8

MEDIATION RESULTS, EXPERIMENT 1: REGRESSION ANALYSIS

	Y = food waste concerns		Y = freezing		Y = accelerated consumption		Y = increased consumption	
	b (se)	*t*	*b* (se)	*t*	*b* (se)	*t*	*b* (se)	*t*
Promotion type								
SUP	−3.743 (4.390)	−0.853	6.710 (5.867)	1.144	13.900 (5.016)	2.771**	5.733 (5.294)	1.083
MUP	13.164 (4.424)	2.976**	33.226 (6.038)	5.503***	17.539 (5.163)	3.397***	14.410 (5.450)	2.645**
Mediator								
Food waste concerns	–	–	0.279 (0.097)	2.878**	0.303 (0.083)	3.652***	0.332 (0.088)	3.791***
Constant	34.646 (3.116)	11.119***	16.152 (5.346)	3.022**	33.737 (4.571)	7.381***	39.655 (4.824)	8.220***
R^2	0.079		0.222		0.145		0.129	
N	192		192		192		192	

$^{\dagger}p < .10$ (two sided).
$^{*}p < .05$ (two sided).
$^{**}p < .01$ (two sided).
$^{***}p < .001$ (two sided).

TABLE 9

MEDIATION RESULTS, EXPERIMENT 1: INDIRECT EFFECTS

	Y = freezing				Y = accelerated consumption				Y = increased consumption			
	Effect	90% CI	95% CI	99% CI	Effect	90% CI	95% CI	99% CI	Effect	90% CI	95% CI	99% CI
SUP	−1.045	−3.541, 0.979	−4.193, 1.423	−5.813, 2.311	−1.134	−3.776, 1.021	−4.420, 1.425	−5.773, 2.291	−1.243	−3.973, 1.136	−4.686, 1.551	−5.945, 2.469
MUP	3.676	0.997, 7.264	0.637, 8.111	0.042, 10.080	3.989	1.420, 7.000	1.042, 7.703	0.370, 9.188	4.370	1.623, 7.602	1.246, 8.460	0.610, 9.864

Notes: Bootstrap confidence intervals are based on 5,000 samples. The same bootstrap samples are used to compute the 90%, 95%, and 99% confidence intervals.

To determine the final set, we started with the promotional calendar obtained from AH for the field study to identify 24 food categories that (at least in the Netherlands) are regularly on a deal and, importantly, differ on the above properties: biscuits and cereal bars; bread; cheese; chilled desserts; chilled fish and seafood; chocolate candy; coffee; cold drinks; cooking sauces, meal kits, and sides; crisps, snacks, nuts, and popcorn; doughnuts, muffins, and cakes; dried pasta, rice, noodles, and couscous; fresh fruit; fresh meat and poultry; fresh ready salad, coleslaw, and sandwich fillers; fresh salad; fresh vegetables; juice, yogurt drinks, and smoothies; ready meals; soup and bouillon; sweets, mints, and chewing gum; table sauces; tea; and yogurt. We then consulted the websites of food retailers in the UK (where we conducted the experiment) to select four foods from each category that participants are likely to have purchased before and, therefore, could evaluate with relative confidence. For example, from "biscuits and cereal bars" we chose cereal bars, chocolate biscuits, cookies, and everyday biscuits. From "fresh fruit," we chose apples, berries, grapes, and oranges. The final set, therefore, comprises 96 foods (web appendix G).

Design and Measures. We assigned 1,201 UK residents recruited via Prolific (M_{age} = 41.77 years, 62.9% female) to one of three conditions: RP, SUP, or MUP. Participants read the following scenario and answered several questions about one food picked at random from every two related categories (e.g., one from "coffee" and "tea" combined, one from "chocolate candy" and "sweets, mints, and chewing gum" combined), for a total of 12 (24 categories divided by two) foods. The text in square brackets refers to the conditions featuring a price promotion, and the text in brace brackets to a specific food. Note that we rephrased the name of several foods to ensure they made sense to UK residents (e.g., "crisps" instead of "chips"):

> "Imagine that you have gone shopping. Amongst other things, you bought the following product: {a bag of apples} [{a bag of apples} at 50% discount/{two bags of apples} on a "two-for-one" promotion]. The product [The product/Each product] has a standard size."

The first question posed to participants was one item of the FWC scale administered in experiment 1: "How concerned would you feel that some of it may be wasted?" (0 = "not concerned at all" to 100 = "extremely concerned"). Participants then provided judgments of convenience ("How convenient is it to consume these products?"), healthiness ("How would you rate the healthiness of these products?"), perishability ("In your opinion, how quickly

do these products perish?"), and versatility ("How would you rate the versatility of these products?"). These properties were presented in random order and measured on separate 100-point bipolar scales (e.g., 0 = "not convenient" to 100 = "convenient"). We explained that foods that are convenient to consume do not require preparation and that foods that are versatile can be consumed on many occasions and settings, or in many dishes. The experimental manipulation did not affect how the 96 foods were judged on any property (all $ps > .13$).

Next, we asked participants whether they purchased each food in the past 2 years and, to check recall, to indicate if a price promotion (and its type) appeared in the scenario. 98.4% of the participants passed this check. Our initial sample comprises 14,412 (1,201 × 12) observations, from which we remove 3,951 observations for which participants indicated not having purchased the corresponding food in the past 2 years, and 108 observations for which, due to an error with Qualtrics, participants skipped this question. The analysis below, therefore, is based on 10,353 observations.

Results and Discussion. The descriptive statistics reported in web appendix G show large differences in FWC across the three conditions for the 96 foods. To understand the generalizability of the relationship between MUPs and FWC across these foods, we regress FWC on dummy variables for the SUP and MUP conditions, and interactions of these two dummy variables with the measures of convenience, healthiness, perishability, and versatility (each of them mean-centered). We use a regression analysis with cluster-robust standard errors (clustered at the participant level, Chernev and Blair 2021) because our data set has an unbalanced panel structure (each participant was assigned to one of three promotion conditions and evaluated 12 out of 96 foods), and to account for repeated measures/within-participant correlation across observations (in which case default standard errors can greatly overstate precision and lead to spurious statistical significance).

In line with experiment 1, the regression estimates in table 10 show that, on average, participants in the MUP condition had higher FWC than participants in the RP condition ($b = 3.497$, $p < .01$). On average, the estimates show no significant difference between participants in the SUP and RP conditions ($p = .54$). In addition, the estimates show a negative main effect of convenience ($b = -0.094$, $p < .001$) and positive main effects of healthiness ($b = 0.032$, $p < .10$) and perishability ($b = 0.282$, $p < .001$), on FWC. The main effect of versatility is not significant ($p = .61$).

Furthermore, we find that the difference in FWC between purchases in the MUP and RP conditions is on average higher for foods that score higher on perishability ($b = 0.183$, $p < .001$) and lower on versatility ($b = -0.052$, $p < .05$). This means that, on average, purchases on a MUP trigger stronger FWC for foods that are relatively more perishable (e.g., fresh meat) and weaker FWC for foods that are relatively more versatile (e.g., mixed peppers). The interactions between the dummy for purchases in the MUP condition and the measures of convenience and healthiness are not significant (both $ps > .90$). This last result is important because it indicates that the effect of MUPs on FWC does not depend on healthiness. Thus, less healthy foods (e.g., muffins) purchased on a MUP also trigger higher FWC on average, which may be problematic if it leads to overconsumption. We come back to this point in the General Discussion. For SUPs, none of the interactions are significant (all $ps > .50$). A robustness check that includes the observations on foods that participants indicated not having purchased in the past 2 years shows similar results, except that the interaction between the dummy for purchases in the MUP condition and the measure of versatility is not significant (web appendix G).

TABLE 10

REGRESSION FOOD WASTE CONCERNS, EXPERIMENT 2

	b (clustered se)	*t*
SUP	0.824 (1.339)	0.616
SUP × convenience	−0.022 (0.033)	−0.677
SUP × healthiness	0.004 (0.025)	0.160
SUP × perishability	−0.005 (0.026)	−0.179
SUP × versatility	−0.008 (0.027)	−0.300
MUP	3.497 (1.190)	2.939**
MUP × convenience	−0.004 (0.032)	−0.126
MUP × healthiness	0.003 (0.024)	0.126
MUP × perishability	0.183 (0.027)	6.832***
MUP × versatility	−0.052 (0.024)	−2.151*
Convenience	−0.094 (0.023)	−4.136***
Healthiness	0.032 (0.017)	1.828†
Perishability	0.282 (0.019)	15.011***
Versatility	−0.009 (0.018)	−0.507
Constant	21.573 (0.896)	24.068***
R^2	0.190	
N	10,353	

Notes: convenience, healthiness, perishability, and versatility are all mean centered.
†$p < .10$ (two sided).
*$p < .05$ (two sided).
**$p < .01$ (two sided).
***$p < .001$ (two sided).

GENERAL DISCUSSION

Food waste is a growing concern with serious economic, environmental, and moral implications. A recurring complaint is that price promotions, and in particular multi-unit deals, exacerbate the problem because they prompt households to purchase in excess of what they need.

The first goal of our research was to clarify the relationship between price promotions and household food waste. To that end, we conducted a large-scale field study in

which we found no evidence of a positive relationship between single-unit or multi-unit price promotions and food waste across eight frequently purchased perishable foods. In fact, households that purchased on a MUP reported wasting less than did households that purchased at RPs, while both consumption and freezing increased. Importantly, we suggested a link to overbuying, as these effects are attenuated when, for a given household, the quantity purchased on a MUP is similar to the quantity typically purchased at RPs.

Next, we proposed and tested a theory of waste prevention that accounts for these findings. One experiment provides support for the hypothesis that, compared to purchasing at RPs, purchasing on a MUP triggers a situational concern for food waste and, in turn, accelerates and increases consumption and prompts freezing. A second experiment that tests the generalizability of the link between MUPs and FWC across foods varying in convenience, healthiness, perishability, and versatility shows that the effect holds for many foods, and specifically for those that are more perishable and less versatile.

Our findings, then, have implications for supermarket retailers and regulators. MUPs are important to many retailers. As such, the decision to restrict or ban them should not be taken lightly and, at least, it requires a solid empirical basis. Back in 2014, the British Retail Council warned "cutting food waste is a key sustainability issue, but we need to focus on evidence-based policy rather than being distracted by perception" (BBC News 2014). We view our research as a step in this direction and join other scholars (Block et al. 2016; van Doorn 2016) in advocating a more nuanced record of when, how, and why food waste occurs.

In addition, our research should appeal to marketing professionals looking to contribute on issues of sustainability. Households are a primary culprit of food waste because they appear late in the supply chain where the accumulated use of resources peaks and uneaten food can only be scrapped. Accordingly, marketers can leverage their understanding of household behavior to contribute solutions. For example, some retailers tested novel deals such as "buy one, get one later" to promote responsible behaviors. Similarly, supermarkets could remind consumers of the option to freeze extra quantities by framing "buy one, get one" deals as "buy one, freeze one."

With respect to the literature, while previous studies on price promotion showed that households compensate for promotion-induced overbuying by consuming and storing more, they typically rely on scanner panel data and assume that all food bought is ultimately consumed. Thus, our work adds to this research by examining an overlooked post-purchase outcome, food waste, and one mechanism that drives it. We show that households cope with promotion-induced overbuying by taking actions that prevent waste—albeit we also show that this is unlikely to be the case generally across all foods. This result complements existing food research because it suggests that people's intuition that price promotions cause waste is inaccurate.

Separately, we contribute to consumer research a conceptualization of waste aversion as a situational factor that can be triggered by something as common as a price deal and that can influence behavior beyond purchase decisions. In our mind, neither of these extensions are obvious. To start, price promotions trigger a concern for food waste only when they entice consumers to overbuy, which is naturally more likely with MUPs.[9] Moreover, while consumers may forgo an attractive price due to concerns about squandered money or utility, less is known about how taking advantage of a price promotion affects such concerns and influences people's actions to prevent waste. Our research, then, advances the understanding of when and why waste aversion surfaces and affects decision-making.

At the same time, we acknowledge limitations in our work that could motivate future research. First, while few would disagree that reducing household food waste is a worthy cause, reducing it at the expense of adding consumption is debatable—especially if extra eating carries consequences for one's health (Mas, Haws, and Goldsmith 2022). Most definitions of food waste, including the one endorsed by the UN that we adopted, do not include overnutrition as an instance of waste (Parfitt et al. 2010). Accordingly, our research is not intended to examine a possible substitution between waste in terms of food scrapped and waste in terms of excess calories ingested (Williamson, Block, and Keller 2016). Nonetheless, we can see merit in taking a broader perspective, in which case future research could try to calibrate the tradeoff and test interventions with the potential to reduce waste in its broader sense.

Similarly, in the field data, we do not observe whether the increased consumption associated with purchases made on a MUP leads households to waste other perishable foods. While we do not anticipate a large effect because most of these products can also be frozen, future research could test this intuition.

Third, we focused on food properties to test the generalizability of our findings knowing that they are typically more actionable for supermarket retailers and regulators than, say, consumer characteristics. However, the list of plausible moderators is likely longer. For example, the waste aversion literature cited earlier suggests several

9 While logic dictates that overbuying is more likely as purchase quantities increase, and therefore naturally more likely with MUPs, we conducted a final follow-up experiment (supplementary experiment 3, web appendix F) in which we show that purchasing on a MUP has no impact on food waste concerns when the required purchase quantity matches the amount consumers usually purchase. This result confirms that the effect is tied to overbuying rather than a specific type of price promotion.

interesting factors that could be included in additional studies including concern for the environment and creative reuse (Haws et al. 2012) and BMI (Raghunathan and Chandrasekaran 2021), among others.

Fourth, the waste aversion literature shows that people shun waste to avoid squandering money (Arkes 1996) and because they dislike unused utility (Bolton and Alba 2012). Price promotion is an interesting context because these sources of waste aversion may play a different role depending on the type of deal offered to consumers. Understanding which source of waste aversion (money vs. unused utility) dominates under which conditions is a promising avenue for future research.

Finally, we believe that there is an opportunity to investigate cultural differences in the way households manage food. For instance, although freezing is common in developed countries, attitudes toward storing food may well vary. Moreover, the availability and size of freezers, as well as the size of food packages, may differ across countries. For instance, the package sizes of foods sold at club stores such as Costco, which are popular in the US, are often much larger than what is available in other countries. This increases the potential for waste but may also lead households to adopt ways to prevent the food from spoiling.

DATA COLLECTION INFORMATION

The field data were collected by GfK in the Netherlands under the supervision of the first author during the first quarter of 2019. The first author analyzed the field data. The data for experiment 1 were collected during week 14 of 2021, the data for experiment 2 were collected during week 46 of 2022, the data for supplementary experiment 1 were collected during week 46 of 2021, the data for supplementary experiment 2 were collected during week 4 of 2022, and the data for supplementary experiment 3 were collected during week 16 of 2021. The data for all experiments were collected on Prolific. The first, second, and fourth authors collected and analyzed these data. All data reported in the article are stored in a Dropbox folder under the management of the first author and all experimental data are stored on the Open Science Framework at https://osf.io/r5nsj.

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